CLAIMS

We Claim:

1. A spatial light modulator comprising:

an array of micromirrors on a substrate, each micromirror having four predominant sides and being held on the substrate by a plurality of posts, wherein the four predominant sides define two diagonals, and wherein a line between any two of the plurality of posts is not coincident with either of the two diagonals.

2. The spatial light modulator of claim 1, wherein each micromirror is in a shape of a rectangle, square, trapezoid or rhombus.

3. The spatial light modulator of claim 2, wherein the micromirror is in a shape of square.

4. The spatial light modulator of claim 1, wherein the plurality of posts consists of two posts.

5. The spatial light modulator of claim 1, wherein the substrate has four predominant sides that form a rectangular shape; and wherein each side of the micromirror is at an angle of from 5° degrees to 25° degrees to the two sides of the rectangular substrate.

6. The spatial light modulator of claim 1, wherein the substrate has four predominant sides that form a rectangular shape; and wherein each side of the micromirror is at an angle of from 10° degrees to 20° degrees to the two sides of the rectangular substrate.

7. The spatial light modulator of claim 1, wherein each micromirror further comprises:

a hinge support held by the posts on the substrate and connected to the substrate via the posts;

a hinge affixed to the hinge support; and

a mirror plate attached to the hinge such that the mirror plate rotates along a rotation axis that is parallel to but offset from a diagonal of the mirror plate when viewed from the top of the substrate.

8. The spatial light modulator of claim 7, wherein the micromirror further comprises:
a first electrode placed proximate to the mirror plate such that a first electrical filed is established between the first electrode and the mirror plate, and the mirror plate rotates relative to the substrate in a first rotation direction in response to the first electrical field.

9. The spatial light modulator of claim 7, wherein the micromirror further comprises:
a second electrode placed proximate to the mirror plate such that a second electrical filed is established between the second electrode and the mirror plate, and the mirror plate rotates relative to the substrate in a second rotation direction in response to the first electrical field, wherein the second rotation direction is opposite to the first rotation direction.

10. The spatial light modulator of claim 9, wherein the first and the second electrode are on a substrate other than the substrate to which the hinge support is connected.

11. The spatial light modulator of claim 9, wherein the first electrode is on a substrate other than the substrate to which the hinge support is connected; and wherein the second electrode is on the substrate to which the hinge support is connected.

12. The spatial light modulator of claim 11, wherein the second electrode is an electrode film on a surface of the substrate to which the hinge support is connected.

13. The spatial light modulator of claim 7, wherein the micromirror further comprises:
an extension plate connected to the mirror plate.

14. The spatial light modulator of claim 13, wherein the extension plate is connected to the mirror plate via an extension-plate post and the extension plate defines a first gap between the extension and the mirror plate.

15. The spatial light modulator of claim 13, wherein the extension plate is extended beyond the mirror plate and connected to the mirror plate via an extension-plate post; and wherein the extension plate defines a second gap between the extension plate and the substrate to which the hinge support is connected.

16. The spatial light modulator of claim 13, wherein the extension plate is electrically conducting.

17. The spatial light modulator of claim 13, wherein the extension plate is dielectric with a dielectric constant larger than 1.0.

18. The spatial light modulator of claim 7, wherein the micromirror further comprises:
a first stop for stopping the rotation of the mirror plate when the mirror plate rotates to an ON state angle.

19. The spatial light modulator of claim 18, wherein the first stop is disposed on the hinge support.

20. The spatial light modulator of claim 7, wherein the micromirror further comprises:
a second stop for stopping the rotation of the mirror plate when the mirror plate rotates to an OFF state.

21. The spatial light modulator of claim 20, wherein second stop is disposed on the hinge support.

22. The spatial light modulator of claim 1, wherein the substrate has an anti-reflection film on a surface of the substrate.

23. A spatial light modulator comprising: a rectangular array of micromirrors on a substrate, each micromirror having four predominant sides, wherein each side is neither parallel nor perpendicular to the edges of the rectangular array.

24. The spatial light modulator of claim 23, wherein each micromirror is in a shape of a rectangle, square, trapezoid or rhombus.

25. The spatial light modulator of claim 24, wherein the micromirror is in a shape of square.

26. The spatial light modulator of claim 23, wherein the plurality of posts consists of two posts.

27. The spatial light modulator of claim 23, wherein the substrate has four predominant sides that form a rectangular shape; and wherein each side of the micromirror is at an angle of from 5° degrees to 25° degrees to the two sides of the rectangular substrate.

28. The spatial light modulator of claim 23, wherein the substrate has four predominant sides that form a rectangular shape; and wherein each side of the micromirror is at an angle of from 10° degrees to 20° degrees to the two sides of the rectangular substrate.

29. The spatial light modulator of claim 23, wherein each micromirror further comprises:

a hinge support held by the posts on the substrate and connected to the substrate via the posts;

a hinge affixed to the hinge support; and

a mirror plate attached to the hinge such that the mirror plate rotates along a rotation axis that is parallel to but offset from a diagonal of the mirror plate when viewed from the top of the substrate.

30. The spatial light modulator of claim 29, wherein the micromirror further comprises:

a first electrode placed proximate to the mirror plate such that a first electrical filed is established between the first electrode and the mirror plate, and the mirror plate rotates relative to the substrate in a first rotation direction in response to the first electrical field.

31. The spatial light modulator of claim 29, wherein the micromirror further comprises:

a second electrode placed proximate to the mirror plate such that a second electrical filed is established between the second electrode and the mirror plate, and the mirror plate rotates relative to the substrate in a second rotation direction in response to the first electrical field, wherein the second rotation direction is opposite to the first rotation direction.

32. The spatial light modulator of claim 31, wherein the first and the second electrode are on a substrate other than the substrate to which the hinge support is connected.

33. The spatial light modulator of claim 31, wherein the first electrode is on a substrate other than the substrate to which the hinge support is connected; and wherein the second electrode is on the substrate to which the hinge support is connected.

34. The spatial light modulator of claim 33, wherein the second electrode is an electrode film on a surface of the substrate to which the hinge support is connected.

35. The spatial light modulator of claim 29, wherein the micromirror further comprises:
an extension plate connected to the mirror plate.

36. The spatial light modulator of claim 35, wherein the extension plate is connected to the mirror plate via an extension-plate post and the extension plate defines a first gap between the extension and the mirror plate.

37. The spatial light modulator of claim 35, wherein the extension plate is extended beyond the mirror plate and connected to the mirror plate via an extension-plate post; and wherein the extension plate defines a second gap between the extension plate and the substrate to which the hinge support is connected.

38. The spatial light modulator of claim 35, wherein the extension plate is electrically conducting.

39. The spatial light modulator of claim 35, wherein the extension plate is dielectric with a dielectric constant larger than 1.0.

40. The spatial light modulator of claim 29, wherein the micromirror further comprises:

a first stop for stopping the rotation of the mirror plate when the mirror plate rotates to an ON state angle.

41. The spatial light modulator of claim 40, wherein the first stop is disposed on the hinge support.

42. The spatial light modulator of claim 29, wherein the micromirror further comprises:

a second stop for stopping the rotation of the mirror plate when the mirror plate rotates to an OFF state.

43. The spatial light modulator of claim 42, wherein second stop is disposed on the hinge support.

44. The spatial light modulator of claim 23, wherein the substrate has an anti-reflection film on a surface of the substrate.

45. A projection system comprising:

a light source;

a spatial light modulator that further comprises an array of micromirrors disposed on a substrate, each micromirror having a rectangular mirror plate held on the substrate;

a condensing lens for directing light from the light source onto the spatial light modulator, wherein light from the light source is directed onto the micromirror array at an incident angle of from 60° to 70° degrees relative to the substrate plane and at an angle of from 50° to 65° degrees relative to a side of the substrate when viewed from the top; and

a projection lens for directing light from the spatial light modulator onto a display target.

46. The projection system of claim 45, wherein the micromirror is in a shape of a square.

47. The projection system of claim 45, wherein the substrate is in a rectangular shape; and wherein each side of the micromirror is at an angle of from 5° degrees to 25° degrees to the two sides of the rectangular substrate.

48. The projection system of claim 45, wherein the substrate is in a rectangular shape; and wherein each side of the micromirror is at an angle of from 10° degrees to 20° degrees to the two sides of the rectangular substrate.

49. The projection system of claim 45, wherein each micromirror further comprises:

a hinge support held by the posts on the substrate and connected to the substrate via the posts;

a hinge affixed to the hinge support; and

a mirror plate attached to the hinge such that the mirror plate rotates along a rotation axis that is parallel to but offset from a diagonal of the mirror plate when viewed from the top of the substrate.

50. The projection system of claim 49, wherein the micromirror further comprises:

a first electrode placed proximate to the mirror plate such that a first electrical filed is established between the first electrode and the mirror plate, and the mirror plate rotates relative to the substrate in a first rotation direction in response to the first electrical field; and

a second electrode placed proximate to the mirror plate such that a second electrical filed is established between the second electrode and the mirror plate, and the mirror plate rotates relative to the substrate in a second rotation direction in response to the first electrical field, wherein the second rotation direction is opposite to the first rotation direction.

51. The projection system of claim 50, wherein the first and the second electrode are on a substrate other than the substrate to which the hinge support is connected.

52. The projection system of claim 50, wherein the first electrode is on a substrate other than the substrate to which the hinge support is connected; and wherein the second electrode is on the substrate to which the hinge support is connected.

53. The projection system of claim 50, wherein the second electrode is an electrode film on a surface of the substrate to which the hinge support is connected.

54. The projection system of claim 51, wherein the micromirror further comprises:
an extension plate connected to the mirror plate.

55. The projection system of claim 54, wherein the extension plate is connected to the mirror plate via an extension-plate post and the extension plate defines a first gap between the extension and the mirror plate.

56. The projection system of claim 54, wherein the extension plate is extended beyond the mirror plate and connected to the mirror plate via an extension-plate post; and wherein the extension plate defines a second gap between the extension plate and the substrate to which the hinge support is connected.

57. The projection system of claim 54, wherein the extension plate is electrically conducting.

58. The projection system of claim 54, wherein the extension plate is dielectric with a dielectric constant larger than 1.0.

59. The projection system of claim 45, wherein the micromirror further comprises:
a first stop for stopping the rotation of the mirror plate when the mirror plate rotates to an ON state angle.

60. The projection system of claim 59, wherein the first stop is disposed on the hinge support.

61. The projection system of claim 59, wherein the micromirror further comprises:
a second stop for stopping the rotation of the mirror plate when the mirror plate rotates to an OFF state.

62 The projection system of claim 45, wherein the substrate has an anti-reflection film on a surface of the substrate.

63. A spatial light modulator comprising: an array of micromirrors on a substrate, each micromirror held on the substrate by a plurality of posts, each micromirror having four predominant sides and wherein the four predominant sides define two diagonals, wherein a line drawn between any two of the posts is not coincident with either of the two diagonals.

64. The spatial light modulator of claim 63, wherein the micromirrors are rectangular or square.

65. The spatial light modulator of claim 63, wherein the substrate is in a rectangular shape; and wherein each side of the micromirror is at an angle of from 5° degrees to 25° degrees to the two sides of the rectangular substrate.

66. The spatial light modulator of claim 63, wherein the substrate is in a rectangular shape; and wherein each side of the micromirror is at an angle of from 10° degrees to 20° degrees to the two sides of the rectangular substrate.

67. The spatial light modulator of claim 63, wherein each micromirror further comprises:

a hinge support held by the posts on the substrate and connected to the substrate via the posts;

a hinge affixed to the hinge support; and

a mirror plate attached to the hinge such that the mirror plate rotates along a rotation axis that is parallel to but offset from a diagonal of the mirror plate when viewed from the top of the substrate.

68. The spatial light modulator of claim 67, wherein the micromirror further comprises:

a first electrode placed proximate to the mirror plate such that a first electrical filed is established between the first electrode and the mirror plate, and the mirror plate rotates relative to the substrate in a first rotation direction in response to the first electrical field; and

a second electrode placed proximate to the mirror plate such that a second electrical filed is established between the second electrode and the mirror plate, and the mirror plate rotates relative to the substrate in a second rotation direction in response to the first electrical field, wherein the second rotation direction is opposite to the first rotation direction.

69. The spatial light modulator of claim 68, wherein the second electrode is an electrode film on a surface of the substrate to which the hinge support is connected.

70. The spatial light modulator of claim 67, wherein the micromirror further comprises:
an extension plate connected to the mirror plate.

71. The spatial light modulator of claim 70, wherein the extension plate is connected to the mirror plate via an extension-plate post and the extension plate defines a first gap between the extension and the mirror plate.

72. The spatial light modulator of claim 70, wherein the extension plate is extended beyond the mirror plate and connected to the mirror plate via an extension-plate post; and wherein the extension plate defines a second gap between the extension plate and the substrate to which the hinge support is connected.

73. The spatial light modulator of claim 63, wherein the micromirror further comprises:
a first stop for stopping the rotation of the mirror plate when the mirror plate rotates to an ON state angle.

74. The spatial light modulator of claim 63, wherein the micromirror further comprises:
a second stop for stopping the rotation of the mirror plate when the mirror plate rotates to an OFF state.

75. A spatial light modulator comprising: an array of micromirrors, wherein imaginary lines connecting centers of each micromirror in the array form an imaginary grid of rows and columns orthogonal to each other, and wherein the edges of the micromirrors are not parallel to either the rows or columns in the imaginary grid.

76. The spatial light modulator of claim 75, wherein the micromirrors are rectangular or square.

77. The spatial light modulator of claim 75, wherein the substrate is in a rectangular shape; and wherein each side of the micromirror is at an angle of from 5° degrees to 25° degrees to the two sides of the rectangular substrate.

78. The spatial light modulator of claim 75, wherein the substrate is in a rectangular shape; and wherein each side of the micromirror is at an angle of from 10° degrees to 20° degrees to the two sides of the rectangular substrate.

79. The spatial light modulator of claim 75, wherein each micromirror further comprises:

a hinge support held by the posts on the substrate and connected to the substrate via the posts;

a hinge affixed to the hinge support; and

a mirror plate attached to the hinge such that the mirror plate rotates along a rotation axis that is parallel to but offset from a diagonal of the mirror plate when viewed from the top of the substrate.

80. The spatial light modulator of claim 79, wherein the micromirror further comprises:

a first electrode placed proximate to the mirror plate such that a first electrical filed is established between the first electrode and the mirror plate, and the mirror plate rotates relative to the substrate in a first rotation direction in response to the first electrical field; and

a second electrode placed proximate to the mirror plate such that a second electrical filed is established between the second electrode and the mirror plate, and the mirror plate rotates relative to the substrate in a second rotation direction in response to the first electrical field, wherein the second rotation direction is opposite to the first rotation direction.

81. The spatial light modulator of claim 80, wherein the second electrode is an electrode film on a surface of the substrate to which the hinge support is connected.

82. The spatial light modulator of claim 79, wherein the micromirror further comprises:
an extension plate connected to the mirror plate.

83. The spatial light modulator of claim 82, wherein the extension plate is connected to the mirror plate via an extension-plate post and the extension plate defines a first gap between the extension and the mirror plate.

84. The spatial light modulator of claim 82, wherein the extension plate is extended beyond the mirror plate and connected to the mirror plate via an extension-plate post; and wherein the extension plate defines a second gap between the extension plate and the substrate to which the hinge support is connected.

85. The spatial light modulator of claim 75, wherein the micromirror further comprises:
a first stop for stopping the rotation of the mirror plate when the mirror plate rotates to an ON state angle.

86. The spatial light modulator of claim 75, wherein the micromirror further comprises:
a second stop for stopping the rotation of the mirror plate when the mirror plate rotates to an OFF state.

87. A spatial light modulator comprising: an array of micromirrors on a substrate, each micromirror held on the substrate by a hinge connected to the micromirror and to two posts on the substrate, each micromirror having an axis of rotation, wherein a line drawn between the two posts is not parallel with the axis of rotation.

88. The spatial light modulator of claim 87, wherein the micromirrors are rectangular or square.

89. The spatial light modulator of claim 87, wherein the substrate is in a rectangular shape; and wherein each side of the micromirror is at an angle of from 5° degrees to 25° degrees to the two sides of the rectangular substrate.

90. The spatial light modulator of claim 87, wherein the substrate is in a rectangular shape; and wherein each side of the micromirror is at an angle of from 10° degrees to 20° degrees to the two sides of the rectangular substrate.

91. The spatial light modulator of claim 87, wherein each micromirror further comprises:

a hinge support held by the posts on the substrate and connected to the substrate via the posts;

a hinge affixed to the hinge support; and

a mirror plate attached to the hinge such that the mirror plate rotates along a rotation axis that is parallel to but offset from a diagonal of the mirror plate when viewed from the top of the substrate.

92. The spatial light modulator of claim 91, wherein the micromirror further comprises:

a first electrode placed proximate to the mirror plate such that a first electrical filed is established between the first electrode and the mirror plate, and the mirror plate rotates relative to the substrate in a first rotation direction in response to the first electrical field; and

a second electrode placed proximate to the mirror plate such that a second electrical filed is established between the second electrode and the mirror plate, and the mirror plate rotates relative to the substrate in a second rotation direction in response to the first electrical field, wherein the second rotation direction is opposite to the first rotation direction.

93. The spatial light modulator of claim 92, wherein the second electrode is an electrode film on a surface of the substrate to which the hinge support is connected.

94. The spatial light modulator of claim 91, wherein the micromirror further comprises:

an extension plate connected to the mirror plate.

95. The spatial light modulator of claim 94, wherein the extension plate is connected to the mirror plate via an extension-plate post and the extension plate defines a first gap between the extension and the mirror plate.

96. The spatial light modulator of claim 94, wherein the extension plate is extended beyond the mirror plate and connected to the mirror plate via an extension-plate post; and wherein the extension plate defines a second gap between the extension plate and the substrate to which the hinge support is connected.

97. The spatial light modulator of claim 87, wherein the micromirror further comprises:

a first stop for stopping the rotation of the mirror plate when the mirror plate rotates to an ON state angle.

98. The spatial light modulator of claim 87, wherein the micromirror further comprises:

a second stop for stopping the rotation of the mirror plate when the mirror plate rotates to an OFF state.

99. A spatial light modulator comprising an array of micromirrors, each micromirror comprising:

a hinge; and

a micromirror plate held via the hinge on a substrate, the micromirror plate being disposed in a plane separate from the hinge and having a diagonal extending across the micromirror plate, the micromirror plate being attached to the hinge such that the micromirror plate can rotate along a rotation axis that is parallel to, but off-set from the diagonal of the micromirror plate when viewed from the top.

100. The spatial light modulator of claim 99, wherein the hinge is disposed on an opposite side of the micromirror plate from the substrate.

101. The spatial light modulator of claim 100, wherein the micromirror plate is substantially square.

102. The spatial light modulator of claim 100, wherein the micromirror plate has a substantially rhombus shape.

103. The spatial light modulator of claim 100, wherein the micromirror plate has a substantially trapezoidal shape.

104. The spatial light modulator of claim 100, wherein the micromirror plate has a substantially rectangular shape.

105. The spatial light modulator of claim 99, wherein the hinge is a torsion hinge and the mirror plate rotates along an axis of rotation corresponding to the location of the torsion hinge.

106. The spatial light modulator of claim 99, wherein axis of rotation is located 0.5 micrometers or more away from the micromirror plate diagonal.

107. The spatial light modulator of claim 106, wherein the axis of rotation is located 1.0 micrometers or more away from the micromirror plate diagonal.

108. The spatial light modulator of claim 107, wherein the axis of rotation is located 2.0 micrometers or more away from the micromirror plate diagonal.

109. The spatial light modulator of claim 99, wherein the point of attachment of the hinge to the micromirror plate is not along the diagonal of the micromirror plate.

110. The spatial light modulator of claim 109, wherein the point of attachment of the hinge to the micromirror plate is at least 0.5 micrometers away from the diagonal of the micromirror plate.

111. The spatial light modulator of claim 110, wherein the point of attachment is at least 1.0 micrometers away from the diagonal.

112. The spatial light modulator of claim 99, wherein the hinge is disposed between the micromirror plate and the substrate.

113. The spatial light modulator of claim 112, wherein when the micromirror plate abuts against the stopping mechanism when it reaches the ON state.

114. The spatial light modulator of claim 112, wherein the OFF state of the micromirrors is at an angle of at least -2 degrees relative to the substrate.

115. The spatial light modulator of claim 114, wherein the OFF state of the micromirrors is at an angle of at least -3 degrees relative to the substrate.

116. The spatial light modulator of claim 115, wherein a set of electrodes are provided for rotating the micromirror to the ON state, and a second set of electrodes are provided for rotating the micromirror to the OFF state.

117. The spatial light modulator of claim 99, wherein the micromirror plate has a diagonal length of 25 microns or less.

118. The spatial light modulator of claim 99, wherein the point of attachment of the hinge to the micromirror plate is located at a point away from the diagonal of the micromirror plate at a distance from 1/40 to 1/3 the length of the diagonal.

119. The spatial light modulator of claim 118, wherein the point of attachment of the hinge to the micromirror plate is located at a point away from the diagonal of the micromirror plate at a distance from 1/20 to 1/4 the length of the diagonal.

120. The spatial light modulator of claim 99, wherein each micromirror comprises a support post for connecting the hinge to the substrate and a stopping mechanism projecting held by the support post for resisting rotation of the micromirror plate, wherein the micromirror impacts the stopping mechanism in the ON state, wherein the micromirror plate is a substantially four sided plate having a diagonal, and wherein the hinge attaches to the micromirror plate at a point at least 0.5 um away from the diagonal, and wherein the hinge is disposed in a plane separate from the mirror plate by a gap of at least 0.1 um.

121. A projection system comprising:

a light source;

the spatial light modulator as set forth in claim 99;

condensing optics, wherein light from the light source is focused onto the array of micro-mirrors;

projection optics for projecting light selectively reflected from the array of micro-mirrors; and

a controller for selectively actuating micro-mirrors in the array of micro-mirrors.

122. A spatial light modulator comprising:

an array of micromirrors on a die, each micromirror having a mirror plate that has four predominant edges, wherein an angle between the edge of the mirror plate and an edge of the die is neither 0° nor $(n \cdot 90)^\circ$ degrees, wherein n is an integer.

123. The spatial light modulator of claim 122, wherein the angle is from 2° to 15° degrees.

124. The spatial light modulator of claim 122, wherein the angle is from 5° to 10° degrees.

125. The spatial light modulator of claim 122, wherein the angle is around 12° degrees.

126. The spatial light modulator of claim 122, wherein the die has four predominant edges; and wherein an angle between the edge of the mirror plate and one of the four predominant edges of the die is neither 0° nor $(n \cdot 90)^\circ$ degrees, wherein n is an integer.